

WHAT IS CLAIMED IS:

1. An optical head comprising:
at least one light source for emitting a beam with a first wavelength
and a beam with a second wavelength that is approximately twice as long as
the first wavelength;

a photodetector; and

at least one diffractive optical element provided in optical paths of
the beams with the first and the second wavelengths,

10 wherein outgoing light from said at least one diffractive optical
element is substantially a second-order diffraction light with respect to the
beam with the first wavelength and is substantially a first-order diffraction
light with respect to the beam with the second wavelength.

2. The optical head according to claim 1,

15 wherein said at least one diffractive optical element has a cross
section substantially of a sawtooth shape, and with respect to the first
wavelength λ_1 , the second wavelength λ_2 , and a refractive index n of a
material of said at least one diffractive optical element, groove depth in the
sawtooth shape is substantially in a range between $2\lambda_1 / (n-1)$ and $\lambda_2 / (n-1)$ in
20 the case of a transmission element, is substantially in a range between λ_1 / n
and $\lambda_2 / 2n$ in the case of a reflection element onto which beams are incident
from a substrate side, and is substantially in a range between λ_1 and $\lambda_2 / 2$ in
the case of a reflection element onto which beams are incident from an air
side.

25 3. The optical head according to claim 1,

wherein said at least one diffractive optical element is an objective
lens for focusing beams on an information recording medium.

4. The optical head according to claim 1,

30 wherein said at least one diffractive optical element is a collimator
lens for collimating beams emitted from said at least one light source
substantially into parallel beams.

5. The optical head according to claim 1,

wherein said at least one diffractive optical element is a
focusing/tracking error signal detection element.

35 6. The optical head according to claim 1,

wherein with respect to the first wavelength λ_1 , a minimum period

Λ_{\min} of said at least one diffractive optical element satisfies a relationship of $\Lambda_{\min} \geq 10\lambda_1$.

7. The optical head according to claim 1,
wherein with respect to the first wavelength λ_1 , a minimum period

5 Λ_{\min} of the diffractive optical element satisfies a relationship of $\Lambda_{\min} \geq 22\lambda_1$.

8. The optical head according to claim 1,

wherein the optical head further comprises a refraction optical element having optical surfaces onto which beams emitted from said at least one light source are incident obliquely, the refraction optical element is

10 provided in optical paths of the beams with the first and the second wavelengths, and a diffraction angle of light diffracted by said at least one diffractive optical element due to variation in wavelength of the beams emitted from said at least one light source and a refraction angle of light refracted by the refraction optical element are changed in directions that
15 enable the beams to be canceled out with each other.

9. The optical head according to claim 8,

wherein said at least one diffractive optical element is a grating with a uniform period.

10. The optical head according to claim 8,

20 wherein said at least one diffractive optical element is positioned in a converging light optical path or a diverging light optical path with a numerical aperture of 0.39 or less, and said at least one diffractive optical element has a uniform period.

11. The optical head according to claim 8,

25 wherein the refraction optical element is a prism with three optical surfaces, and when in the three optical surfaces, a surface on a side of an information recording medium is a first surface, a surface on a side of said at least one light source is a second surface, and a surface other than those is a third surface, the refraction optical element is designed so that the beams
30 emitted from said at least one light source pass through the second surface, are reflected by the first and the third surfaces sequentially, and then pass through the first surface, and a bottom part of an objective lens is located lower than a highest position of the beams entering the second surface that have been emitted from said at least one light source.

12. The optical head according to claim 11,

35 wherein a glass material of the prism has an Abbe number of at

least 64.

13. The optical head according to claim 1,
wherein said light source is an SHG light source that emits beams
with two wavelengths.

5 14. The optical head according to claim 1,
wherein the optical head further comprises a transparent substrate
in which the beams with the first and the second wavelengths propagate in a
zigzag manner, and said at least one diffractive optical element is positioned
on the transparent substrate.

10 15. The optical head according to claim 1,
wherein the first wavelength λ_1 satisfies a relationship of $0.35\mu\text{m} \leq \lambda_1 \leq 0.44\mu\text{m}$ or the second wavelength λ_2 satisfies a relationship of $0.76\mu\text{m} \leq \lambda_2 \leq 0.88\mu\text{m}$.

15 16. The optical head according to claim 1,
wherein the first wavelength λ_1 satisfies substantially a relationship
of $0.35\mu\text{m} \leq \lambda_1 \leq 0.44\mu\text{m}$, and said at least one diffractive optical element
is a chromatic-aberration compensation element for compensating chromatic
aberration caused by an objective lens for focusing beams on an information
recording medium.

20 17. An optical head comprising:
at least one light source for emitting a beam with a first wavelength
and a beam with a second wavelength that is approximately twice as long as
the first wavelength;

25 a photodetector;
an objective lens for focusing beams on an information recording
medium; and

a diffractive optical element provided in optical paths of the beams
with the first and the second wavelengths,

30 wherein the diffractive optical element is a chromatic-aberration
compensation element that compensates chromatic aberration caused by the
objective lens and that has difference in level of a step-like shape or grooves
substantially of a sawtooth shape, and with respect to the first wavelength λ_1 ,
the second wavelength λ_2 , and a refractive index n of a material of the
chromatic-aberration compensation element, the difference in level or depth
35 of the grooves is in a range substantially between $2\lambda_1 / (n-1)$ and $\lambda_2 / (n-1)$.

18. The optical head according to claim 17,

wherein the first wavelength λ_1 satisfies a relationship of $0.35\mu\text{m} \leq \lambda_1 \leq 0.44\mu\text{m}$ or the second wavelength λ_2 satisfies a relationship of $0.76\mu\text{m} \leq \lambda_2 \leq 0.88\mu\text{m}$.

19. The optical head according to claim 17,
5 wherein the chromatic-aberration compensation element is formed on the objective lens.

20. The optical head according to claim 17,
wherein the chromatic-aberration compensation element and the objective lens are driven together by an actuator.

10 21. The optical head according to claim 17,
wherein the chromatic-aberration compensation element is a convex diffractive lens and forms converging light in cooperation with the objective lens.

22. An optical head comprising:
15 at least one light source for emitting a beam with a first wavelength, a beam with a second wavelength that is approximately twice as long as the first wavelength, and a beam with a third wavelength that is approximately 1.5 times as long as the first wavelength;

a photodetector; and
20 at least one diffractive optical element provided in optical paths of the beams with the first, the second, and the third wavelengths,
wherein outgoing light from said at least one diffractive optical element is substantially a fourth-order diffraction light with respect to the beam with the first wavelength, is substantially a second-order diffraction
25 light with respect to the beam with the second wavelength, and is substantially a third-order diffraction light with respect to the beam with the third wavelength.

23. The optical head according to claim 22,
wherein said at least one diffractive optical element has a cross
30 section substantially of a sawtooth shape, and with respect to the first wavelength λ_1 , the second wavelength λ_2 , the third wavelength λ_3 , and a refractive index n of a material of said at least one diffractive optical element, groove depth in the sawtooth shape is substantially in a range between a minimum and a maximum among $4\lambda_1 / (n-1)$, $2\lambda_2 / (n-1)$, and $3\lambda_3 / (n-1)$ in the
35 case of a transmission element, is substantially in a range between a minimum and a maximum among $2\lambda_1 / n$, λ_2 / n , and $3\lambda_3 / 2n$ in the case of a

reflection element onto which beams are incident from a substrate side, and is substantially in a range between a minimum and a maximum among $2\lambda_1$, λ_2 , and $3\lambda_3 / 2$ in the case of a reflection element onto which beams are incident from an air side.

5 24. The optical head according to claim 22,
 wherein with respect to the first wavelength λ_1 , a minimum period Λ_{\min} of said at least one diffractive optical element satisfies a relationship of $\Lambda_{\min} \geq 22\lambda_1$.

10 25. The optical head according to claim 22,
 wherein the first wavelength λ_1 satisfies a relationship of $0.35\mu\text{m} \leq \lambda_1 \leq 0.44\mu\text{m}$, the second wavelength λ_2 satisfies a relationship of $0.76\mu\text{m} \leq \lambda_2 \leq 0.88\mu\text{m}$, or the third wavelength λ_3 satisfies a relationship of $0.57\mu\text{m} \leq \lambda_3 \leq 0.68\mu\text{m}$.

15 26. The optical head according to claim 22,
 wherein the first wavelength λ_1 satisfies substantially a relationship of $0.35\mu\text{m} \leq \lambda_1 \leq 0.44\mu\text{m}$, and said at least one diffractive optical element is a chromatic-aberration compensation element for compensating chromatic aberration caused by an objective lens for focusing beams on an information recording medium.

20 27. An optical head comprising:
 at least one light source for emitting a beam with a first wavelength, a beam with a second wavelength that is approximately twice as long as the first wavelength, and a beam with a third wavelength that is approximately 1.5 times as long as the first wavelength;

25 a photodetector;
 an objective lens for focusing beams on an information recording medium; and

 at least one diffractive optical element provided in optical paths of the beams with the first, the second, and the third wavelengths,

30 wherein said at least one diffractive optical element is a chromatic-aberration compensation element that compensates chromatic aberration caused by the objective lens and has difference in level of a step-like shape or grooves substantially of a sawtooth shape, and with respect to the first wavelength λ_1 , the second wavelength λ_2 , the third wavelength λ_3 , and a refractive index n of a material of said at least one diffractive optical element,
35 the difference in level or depth of the grooves is in a range between a

minimum and a maximum among $4\lambda_1 / (n-1)$, $2\lambda_2 / (n-1)$, and $3\lambda_3 / (n-1)$.

28. The optical head according to claim 27,

wherein the first wavelength λ_1 satisfies a relationship of $0.35\mu\text{m} \leq \lambda_1 \leq 0.44\mu\text{m}$, the second wavelength λ_2 satisfies a relationship of $0.76\mu\text{m} \leq \lambda_2 \leq 0.88\mu\text{m}$, or the third wavelength λ_3 satisfies a relationship of $0.57\mu\text{m} \leq \lambda_3 \leq 0.68\mu\text{m}$.

29. The optical head according to claim 27,

wherein the chromatic-aberration compensation element is formed on the objective lens.

30. The optical head according to claim 27,

wherein the chromatic-aberration compensation element and the objective lens are driven together by an actuator.

31. The optical head according to claim 27,

wherein the chromatic-aberration compensation element is a convex diffractive lens and forms converging light in cooperation with the objective lens.

32. An optical head comprising:

at least one light source for emitting a beam with a first wavelength and a beam with a second wavelength that is approximately 1.5 times as long as the first wavelength;

a photodetector; and

at least one diffractive optical element provided in optical paths of the beams with the first and the second wavelengths,

wherein outgoing light from said at least one diffractive optical element is substantially a third-order diffraction light with respect to the beam with the first wavelength and is substantially a second-order diffraction light with respect to the beam with the second wavelength.

33. The optical head according to claim 32,

wherein said at least one diffractive optical element has a cross section substantially of a sawtooth shape, and with respect to the first wavelength λ_1 , the second wavelength λ_2 , and a refractive index n of a material of said at least one diffractive optical element, groove depth in the sawtooth shape is substantially in a range between $3\lambda_1 / (n-1)$ and $2\lambda_2 / (n-1)$ in the case of a transmission element, is substantially in a range between $3\lambda_1 / 2n$ and λ_2 / n in the case of a reflection element onto which beams are incident from a substrate side, and is substantially in a range between $3\lambda_1 / 2$

and λ_2 in the case of a reflection element onto which beams are incident from an air side.

34. The optical head according to claim 32,

wherein with respect to the first wavelength λ_1 , a minimum period
5 Λ_{\min} of said at least one diffractive optical element satisfies a relationship of
 $\Lambda_{\min} \geq 16\lambda_1$.

35. The optical head according to claim 32,

wherein the first wavelength λ_1 satisfies a relationship of $0.35\mu\text{m} \leq$
10 $\lambda_1 \leq 0.44\mu\text{m}$ or the second wavelength λ_2 satisfies a relationship of $0.57\mu\text{m}$
 $\leq \lambda_2 \leq 0.68\mu\text{m}$.

36. The optical head according to claim 32,

wherein the first wavelength λ_1 satisfies substantially a relationship
of $0.35\mu\text{m} \leq \lambda_1 \leq 0.44\mu\text{m}$, and said at least one diffractive optical element
is a chromatic-aberration compensation element for compensating chromatic
15 aberration caused by an objective lens for focusing beams on an information
recording medium.

37. An optical head comprising:

at least one light source for emitting a beam with a first wavelength
and a beam with a second wavelength that is approximately 1.5 times as
20 long as the first wavelength;

a photodetector;

an objective lens for focusing beams on an information recording
medium; and

a diffractive optical element provided in optical paths of the beams
25 with the first and the second wavelengths,

wherein the diffractive optical element is a chromatic-aberration
compensation element that compensates chromatic aberration caused by the
objective lens and that has difference in level of a step-like shape or grooves
substantially of a sawtooth shape, and with respect to the first wavelength λ_1 ,
30 the second wavelength λ_2 , and a refractive index n of a material of the
chromatic-aberration compensation element, the difference in level or depth
of the grooves is substantially in a range between $3\lambda_1 / (n-1)$ and $2\lambda_2 / (n-1)$.

38. The optical head according to claim 37,

wherein the first wavelength λ_1 satisfies a relationship of $0.35\mu\text{m} \leq$
35 $\lambda_1 \leq 0.44\mu\text{m}$ or the second wavelength λ_2 satisfies a relationship of $0.57\mu\text{m}$
 $\leq \lambda_2 \leq 0.68\mu\text{m}$.

39. The optical head according to claim 37,
wherein the chromatic-aberration compensation element is formed
on the objective lens.

40. The optical head according to claim 37,
wherein the chromatic-aberration compensation element and the
objective lens are driven together by an actuator.

41. The optical head according to claim 37,
wherein the chromatic-aberration compensation element is a convex
diffractive lens and forms converging light in cooperation with the objective
lens.

42. An optical head comprising:
at least one light source for emitting a beam with a first wavelength,
a beam with a second wavelength that is approximately twice as long as the
first wavelength, and a beam with a third wavelength that is approximately
1.5 times as long as the first wavelength;
a photodetector; and
at least one diffractive optical element provided in optical paths of
the beams with the first, the second, and the third wavelengths,
wherein outgoing light from said at least one diffractive optical
element is substantially a sixth-order diffraction light with respect to the
beam with the first wavelength, is substantially a third-order diffraction
light with respect to the beam with the second wavelength, and is
substantially a fourth-order diffraction light with respect to the beam with
the third wavelength.

43. The optical head according to claim 42,
wherein said at least one diffractive optical element has a cross
section substantially of a sawtooth shape, and with respect to the first
wavelength λ_1 , the second wavelength λ_2 , the third wavelength λ_3 , and a
refractive index n of a material of said at least one diffractive optical element,
groove depth in the sawtooth shape is substantially in a range between a
minimum and a maximum among $6\lambda_1 / (n-1)$, $3\lambda_2 / (n-1)$, and $4\lambda_3 / (n-1)$ in the
case of a transmission element, is substantially in a range between a
minimum and a maximum among $3\lambda_1 / n$, $3\lambda_2 / 2n$, and $2\lambda_3 / n$ in the case of a
reflection element onto which beams are incident from a substrate side, and
is substantially in a range between a minimum and a maximum among $3\lambda_1$,
 $3\lambda_2 / 2$, and $2\lambda_3$ in the case of a reflection element onto which beams are

incident from an air side.

44. An optical head comprising:

at least one light source for emitting a beam with a first wavelength,
a beam with a second wavelength that is approximately twice as long as the
5 first wavelength, and a beam with a third wavelength that is approximately
1.5 times as long as the first wavelength;

a photodetector;

an objective lens for focusing beams on an information recording
medium; and

10 at least one diffractive optical element provided in optical paths of
the beams with the first, the second, and the third wavelengths,

wherein said at least one diffractive optical element is a chromatic-
aberration compensation element that compensates chromatic aberration
caused by the objective lens and that has difference in level of a step-like
15 shape or grooves substantially of a sawtooth shape, and with respect to the
first wavelength λ_1 , the second wavelength λ_2 , the third wavelength λ_3 , and a
refractive index n of a material of said at least one diffractive optical element,
the difference in level or depth of the grooves is substantially in a range
between a minimum and a maximum among $6\lambda_1 / (n-1)$, $3\lambda_2 / (n-1)$, and $4\lambda_3 /$
20 $(n-1)$.

45. The optical head according to claim 44,

wherein the chromatic-aberration compensation element is formed
on the objective lens.

46. The optical head according to claim 44,

25 wherein the chromatic-aberration compensation element and the
objective lens are driven together by an actuator.

47. The optical head according to claim 44,

wherein the chromatic-aberration compensation element is a convex
diffractive lens and forms converging light in cooperation with the objective
30 lens.

48. An optical head comprising:

a light source emitting a beam with a wavelength λ that satisfies
substantially a relationship of $0.35\mu\text{m} \leq \lambda \leq 0.44\mu\text{m}$;

a photodetector; and

35 at least one diffractive optical element provided in an optical path of
the beam emitted from the light source,

wherein said at least one diffractive optical element is a chromatic-aberration compensation element for compensating chromatic aberration caused by an objective lens for focusing beams on an information recording medium.

5 49. The optical head according to claim 48,
 wherein the chromatic-aberration compensation element is formed
on the objective lens.

 50. The optical head according to claim 48,
 wherein the chromatic-aberration compensation element and the
10 objective lens are driven together by an actuator.

 51. The optical head according to claim 48,
 wherein the chromatic-aberration compensation element is a convex
diffractive lens and forms converging light in cooperation with the objective
lens.

